REMARKS

This application has been reviewed in light of the Office Action mailed on September 9, 2004. Claims 1-18 are pending in the application. Claims 1 and 10 are in independent form. By the present amendment, Claims 1-9 have been amended and Claims 10-18 have been added. No new matter or issues are believed to be introduced by the amendments.

Claims 2-9 have been amended to better comport with US practice. Specifically, the term "characterized in that" has been amended to recite "wherein" throughout the claims.

In the Office Action, the Examiner rejected Claims 1-9 under the judicially created doctrine of obviousness-type double patenting as being unpatentable over Claims 1, 2 and 6-8 of co-pending Application No. 10/056,096. Claim 1 of the present application, as well as Claim 1 of the co-pending application, have been amended in a manner which is believed to obviate the provisional obviousness-type double patenting rejection over Claims 1, 2 and 6-8 of co-pending Application No. 10/056,096. Accordingly, withdrawal of the provisional obviousness-type double patenting rejection with respect to Claims 1-9 of the present application is respectfully requested.

Further, in the Office Action, Claims 1-6 were rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 6,002,367A issued to Engblom et al. on December 14, 1999 ("Engblom et al."). Claim 1 has been amended to better define Applicants' invention and to overcome the cited rejection.

Claim 1 now recites:

A wireless terminal comprising <u>a ground conductor housing having predetermined dimensions and a transceiver housed by said ground conductor housing</u> and coupled to an antenna feed, <u>wherein the antenna feed is coupled to the ground conductor housing in a</u>

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predetermined manner such that a change in said predetermined dimensions of said ground conductor housing results in a change in the bandwidth of said wireless terminal. (Emphasis Added) Support for the amendments can be found at page 5, lines 16-30 of the specification.

Engblom et al. is directed to an antenna device for placement inside and parallel to a non-conductive chassis or housing of an electrical device, such as a telephone. All of the components of the antenna device are situated inside the chassis and no component of the antenna device is coupled to the chassis. With the electrical device described by Engblom et al., a change in the dimensions of the chassis or housing would not result in a change in the bandwidth of the electrical device.

Hence, Engblom et al. does not disclose or suggest a wireless terminal comprising a ground conductor housing having predetermined dimensions, wherein an antenna feed is coupled to the ground conductor housing in a predetermined manner such that a change in the predetermined dimensions of the ground conductor housing results in a change in the bandwidth of the wireless terminal, as recited by Applicants' amended, independent Claim 1. Accordingly, withdrawal of the rejection with respect to Claim 1 and allowance thereof are respectfully requested.

Claims 2-6 depend from Claim 1, and therefore include the limitations of Claim 1. Hence, for the same reasons given above for Claim 1, Claims 2-6 are believed to contain patentable subject matter. Accordingly, withdrawal of the rejection with respect to Claims 2-6 and allowance thereof are respectfully requested.

Claims 7-9 were rejected under 35 U.S.C. §103(a) as being unpatentable over Engblom et al. in view of U.S. Patent No. 6,424,300B1 issued to Sanford et al. on July 23, 2002 ("Sanford et al."). The rejection is respectfully traversed.

U.S. Patent No. 6,424,300B1 issued to Sanford et al. is based on a patent application filed on October 27, 2000. The patent application does not claim priority to an earlier filing date. The subject patent application has an earlier filing date of August 8, 2000. A copy of the earlier filed application is submitted herewith. The earlier filed patent application includes support for the subject matter recited by Claims 7-9. Accordingly, U.S. Patent No. 6,424,300B1 is not proper prior art with respect to Applicants' patent application.

Further, Claims 7-9 depend from Claim 1, and therefore include the limitations of Claim 1. Hence, for the same reasons given above for Claim 1, Claims 7-9 are believed to contain patentable subject matter. Accordingly, withdrawal of the rejection with respect to Claims 7-9 and allowance thereof are respectfully requested.

In view of the foregoing amendments and remarks, it is respectfully submitted that all claims presently pending in the application, namely, Claims 1-18, are believed to be in condition for allowance and patentably distinguishable over the art of record.

If the Examiner should have any questions concerning this communication or feels that an interview would be helpful, the Examiner is requested to call Dicran Halajian, Esq., Intellectual Property Counsel, Philips Electronics North America, at 914-333-9607.

Respectfully submitted,

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Reg. No. 51,356
Attorney for Applicants

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P.O. Box 3001
345 Scarborough Road
Briarcliff Manor, New York 10510-8001

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2.	Patent application number *(The Patent Office will fill in this part)*	0019335.9 — 8 AUG 2000
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	Patents ADP Number *(if you know it)*	7419294001
	If the applicant is a corporate body, give the country/state of its incorporation	THE NETHERLANDS
4.	Title of the invention	WIRELESS TERMINAL
5.	Name of your agent *(if you have one)*	KEVIN JAMES SCOTT
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	Patents ADP number *(if you know it)*	7688914001
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Signature Date 7th August 2000

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DESCRIPTION

WIRELESS TERMINAL

The present invention relates to a wireless terminal, for example a mobile phone handset.

Wireless terminals, such as mobile phone handsets, typically incorporate either an external antenna, such as a normal mode helix or meander line antenna, or an internal antenna, such as a Planar Inverted-F Antenna (PIFA) or similar.

Such antennas are small (relative to a wavelength) and therefore, owing to the fundamental limits of small antennas, narrowband. However, cellular radio communication systems typically have a fractional bandwidth of 10% or more. To achieve such a bandwidth from a PIFA for example requires a considerable volume, there being a direct relationship between the bandwidth of a patch antenna and its volume, but such a volume is not readily available with the current trends towards small handsets. Hence, because of the limits referred to above, it is not feasible to achieve efficient wideband radiation from small antennas in present-day wireless terminals.

A further problem with known antenna arrangements for wireless terminals is that they are generally unbalanced, and therefore couple strongly to the terminal case. As a result a significant amount of radiation emanates from the terminal itself rather than the antenna.

An object of the present invention is to provide a wireless terminal having efficient radiation properties over a wide bandwidth.

According to the present invention there is provided a wireless terminal comprising a ground conductor and a transceiver coupled to an antenna feed, wherein the antenna feed is coupled directly to the ground conductor.

The present invention is based upon the recognition, not present in the prior art, that the impedances of an antenna and a wireless handset are similar to those of an asymmetric dipole, which are separable, and on the further

recognition that the antenna impedance can be replaced with a non-radiating coupling element.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, wherein:

Figure 1 shows a model of an asymmetrical dipole antenna, representing the combination of an antenna and a wireless terminal;

Figure 2 is a graph demonstrating the separability of the components of the impedance of an asymmetrical dipole;

Figure 3 is an equivalent circuit of the combination of a handset and an antenna;

Figure 4 is an equivalent circuit of a capacitively back-coupled handset;

Figure 5 is a perspective view of a basic capacitively back-coupled handset;

Figure 6 is a graph of simulated return loss S_{11} in dB against frequency f in MHz for the handset of Figure 5;

Figure 7 is a Smith chart showing the simulated impedance of the handset of Figure 5 over the frequency range 1000 to 2800MHz;

Figure 8 is a graph showing the simulated resistance of the handset of Figure 5;

Figure 9 is a perspective view of a narrow capacitively back-coupled handset;

Figure 10 is a graph showing the simulated resistance of the handset of Figure 9;

Figure 11 is a perspective view of a slotted capacitively back-coupled handset;

Figure 12 is a graph of simulated return loss S_{11} in dB against frequency f in MHz for the handset of Figure 11; and

Figure 13 is a Smith chart showing the simulated impedance of the handset of Figure 5 over the frequency range 1000 to 2800MHz.

In the drawings the same reference numerals have been used to indicate corresponding features.

Figure 1 shows a model of the impedance seen by a transceiver, in transmit mode, in a wireless handset at its antenna feed point. The impedance is modelled as an asymmetrical dipole, where the first arm 102 represents the impedance of the antenna and the second arm 104 the impedance of the handset, both arms being driven by a source 106. As shown in the figure, the impedance of such an arrangement is substantially equivalent to the sum of the impedance of each arm 102,104 driven separately against a virtual ground 108. The model could equally well be used for reception by replacing the source 106 by an impedance representing that of the transceiver, although this is rather more difficult to simulate.

The validity of this model was checked by simulations using the well-known NEC (Numerical Electromagnetics Code) with the first arm 102 having a length of 40mm and a diameter of 1mm and the second arm 104 having a length of 80mm and a diameter of 1mm. Figure 2 shows the results for the real and imaginary parts of the impedance (R+jX) of the combined arrangement (Ref R and Ref X) together with results obtained by simulating the impedances separately and summing the result. It can be seen that the results of the simulations are quite close. The only significant deviation is in the region of half-wave resonance, when the impedance is difficult to simulate accurately.
An equivalent circuit for the combination of an antenna and a handset, as seen from the antenna feed point, is shown in Figure 3. R_1 and jX_1 represent the impedance of the antenna, while R_2 and jX_2 represent the impedance of the handset. From this equivalent circuit it can be deduced that the ratio of power radiated by the antenna, P_1, and the handset, P_2, is given by

$$\frac{P_1}{P_2} = \frac{R_1}{R_2}$$

If the size of the antenna is reduced, its radiation resistance R_1 will also reduce. If the antenna becomes infinitesimally small its radiation resistance R_1 will fall to zero and all of the radiation will come from the handset. This situation can be made beneficial if the handset impedance is suitable for the source 106 driving it and if the capacitive reactance of the infinitesimal

antenna can be minimised by increasing the capacitive back-coupling to the handset.

With these modifications, the equivalent circuit is modified to that shown in Figure 4. The antenna has therefore been replaced with a physically very small back-coupling capacitor, designed to have a large capacitance for maximum coupling and minimum reactance. The residual reactance of the back-coupling capacitor can be tuned out with a simple matching circuit. By correct design of the handset, the resulting bandwidth can be much greater than with a conventional antenna and handset combination, because the handset acts as a low Q radiating element (simulations show that a typical Q is around 1), whereas conventional antennas typically have a Q of around 50.

A basic embodiment of a capacitively back-coupled handset is shown in Figure 5. A handset 502 has dimensions of 10×40×100mm, typical of modern cellular handsets. A parallel plate capacitor 504, having dimensions 2×10×10mm, is formed by mounting a 10×10mm plate 506 2mm above the top edge 508 of the handset 502, in the position normally occupied by a much larger antenna. The resultant capacitance is about 0.5pF, representing a compromise between capacitance (which would be increased by reducing the separation of the handset 502 and plate 504) and coupling effectiveness (which depends on the separation of the handset 502 and plate 504). The capacitor is fed via a support 510, which is insulated from the handset case 502.

The return loss S_{11} of this embodiment after matching was simulated using the High Frequency Structure Simulator (HFSS), available from Ansoft Corporation, with the results shown in Figure 6 for frequencies f between 1000 and 2800MHz. A conventional two inductor "L" network was used to match at 1900MHz. The resultant bandwidth at 7dB return loss (corresponding to approximately 90% of input power radiated) is approximately 60MHz, or 3%, which is useful but not as large as was required. A Smith chart illustrating the simulated impedance of this embodiment over the same frequency range is shown in Figure 7.

The low bandwidth is because the handset 502 presents an impedance of approximately 3−j90Ω at 1900MHz. Figure 8 shows the resistance variation, over the same frequency range as before, simulated using HFSS. This can be improved by redesigning the case to increase the resistance.

One way in which this can be done is to reduce the width of the handset 502, since the resistance will increase in much the same way as that of a dipole when its radius is decreased. Figure 9 shows a second embodiment having a narrow capacitively back-coupled handset 902. The handset 902 has dimensions of 10×10×100mm, while the dimensions of the capacitor 504, formed from the plate 506 and top surface 908 of the handset 902, and the support 510 are unchanged from the previous embodiment. Simulations were again performed to determine the resistance variation of this embodiment, with the results shown in Figure 10. This clearly demonstrates that use of a narrow handset provides a wider bandwidth where the resistance is higher than that of the basic configuration. The length of the handset could be optimised to give a wide bandwidth centred on a particular frequency, by shifting the resonant frequencies of the structure. For a fixed length handset, a horizontal slot (i.e. a slot across the width of the handset) could be used for the purpose of electrically shortening or lengthening the handset.

An alternative way of increasing the resistance of the case is the insertion of a vertical slot (i.e. a slot parallel to the length, or major axis, of the handset). Figure 11 shows a third embodiment having a slotted capacitively back-coupled handset 1102, with a 33mm deep slot 1112 in the case, together with a capacitor 504. The dimensions of the capacitor 504, formed from the plate 506 and top surface 1108 of the handset 1102, and the support 510 are unchanged from the previous embodiments. The presence of the slot 1112 significantly increases the resistance of the case, as seen by the transceiver, in the region of 1900MHz, allowing the low-Q case to be matched to 50Ω without a significant loss of bandwidth.

The return loss S_{11} of this embodiment was again simulated using HFSS, with the results shown in Figure 12 for frequencies f between 1000 and 2800MHz, using a similar two inductor matching network to that used for the

basic embodiment. The resultant bandwidth at 7dB return loss is greatly improved at approximately 350MHz, or 18%, which is approaching that required to cover UMTS and DCS 1800 bands simultaneously. A Smith chart illustrating the simulated impedance of this embodiment over the same frequency range is shown in Figure 13.

The embodiments disclosed above are based on capacitive coupling. However, any other sacrificial (non-radiating) coupling element could be used instead, for example inductive coupling. Also, the coupling element could be altered in order to aid impedance matching. For example, capacitive coupling could be achieved via an inductive element. This would allow easier matching to yield a more wideband response.

In the above embodiments a conducting handset case has been the radiating element. However, other ground conductors in a wireless terminal could perform a similar function. Examples include conductors used for EMC shielding and an area of Printed Circuit Board (PCB) metallisation, for example a ground plane.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design, manufacture and use of wireless terminals and component parts thereof, and which may be used instead of or in addition to features already described herein. Although claims have been formulated in this application to particular combinations of features, it should be understood that the scope of the disclosure of the present application also includes any novel feature or any novel combination of features disclosed herein either explicitly or implicitly or any generalisation thereof, whether or not it relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants hereby give notice that new claims may be formulated to such features and/or combinations of features during the prosecution of the present application or of any further application derived therefrom.

In the present specification and claims the word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. Further, the word "comprising" does not exclude the presence of other elements or steps than those listed.

CLAIMS

1. A wireless terminal comprising a ground conductor and a transceiver coupled to an antenna feed, wherein the antenna feed is coupled directly to the ground conductor.

2. A terminal as claimed in claim 1, characterised in that the antenna feed is coupled to the ground conductor via a capacitor.

3. A terminal as claimed in claim 2, characterised in that the capacitor is a parallel plate capacitor formed by a conducting plate and a portion of the ground conductor.

4. A terminal as claimed in any one of claims 1 to 3, characterised in that a slot is provided in the ground conductor.

5. A terminal as claimed in claim 4, characterised in that the slot is parallel to the major axis of the terminal.

6. A terminal as claimed in any one of claims 1 to 5, characterised in that the ground conductor is a handset case.

7. A terminal as claimed in any one of claims 1 to 5, characterised in that the ground conductor is a printed circuit board ground plane.

8. A terminal as claimed in any one of claims 1 to 7, characterised in that a matching network is provided between the transceiver and the antenna feed.

9. A wireless terminal substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

ABSTRACT

WIRELESS TERMINAL

A wireless terminal comprises a ground conductor (1102) and a transceiver coupled to an antenna feed, the antenna feed being coupled directly to the ground conductor (1102). In one embodiment the ground conductor is a conducting case (1102). The coupling may be via a parallel plate capacitor (504) formed by a plate (506) and a surface (1108) of the case (1102). The case (1102) acts as an efficient, wideband radiator, eliminating the need for a separate antenna. In a modification of this embodiment a slot (1112) is provided to increase the resistance of the case (1102) as seen by the transceiver, thereby increasing the radiating bandwidth of the terminal.

(Figure 11)

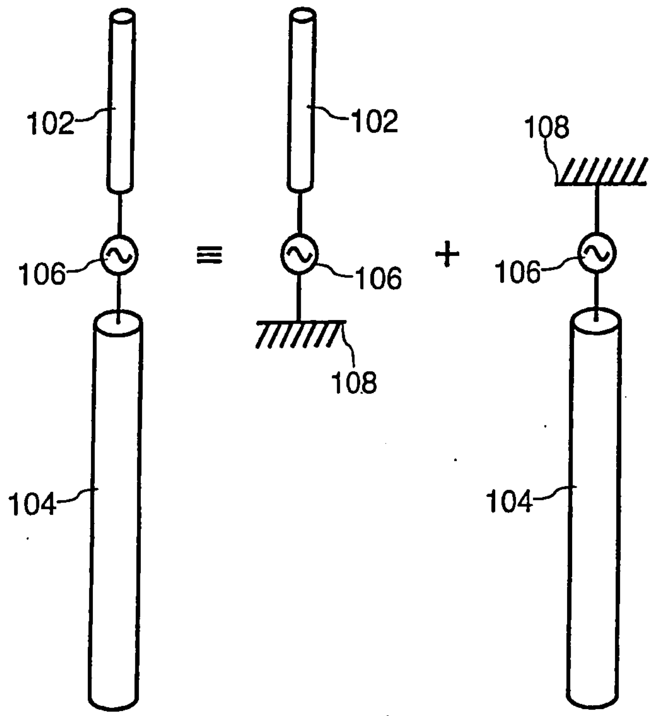
102
102
108
106
106
106
108
104
104

FIG. 1

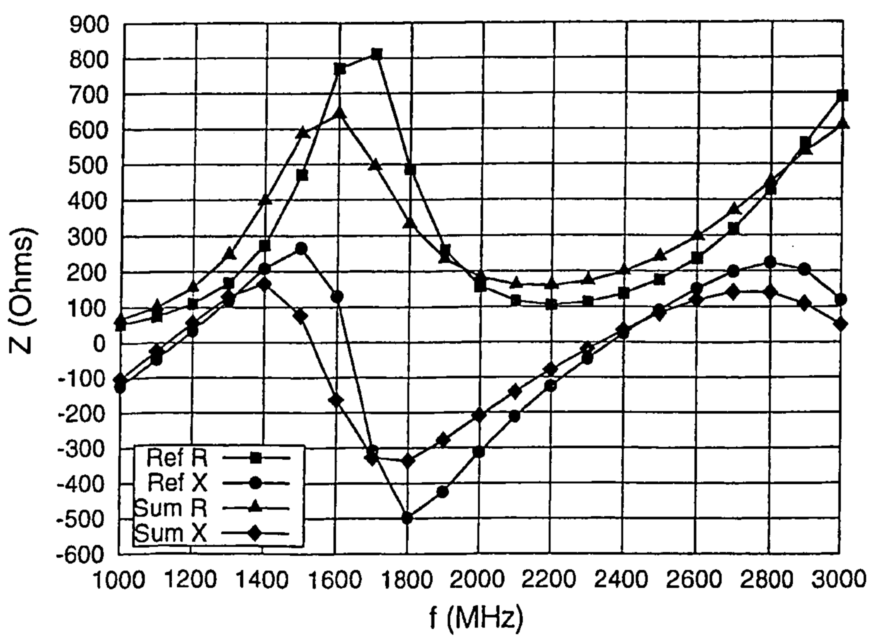
900
800
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
Z (Ohms)
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
f (MHz)
Ref R
Ref X
Sum R
Sum X

FIG. 2

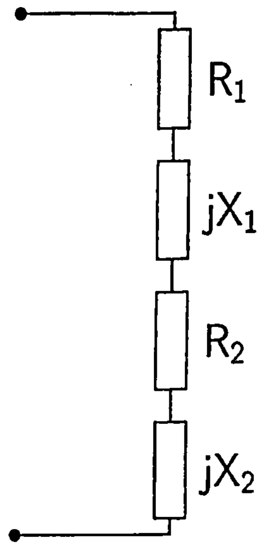

FIG. 3

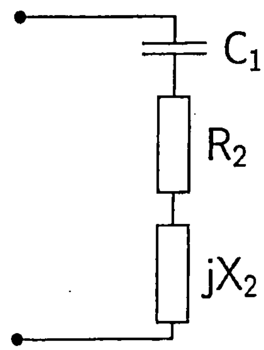

FIG. 4

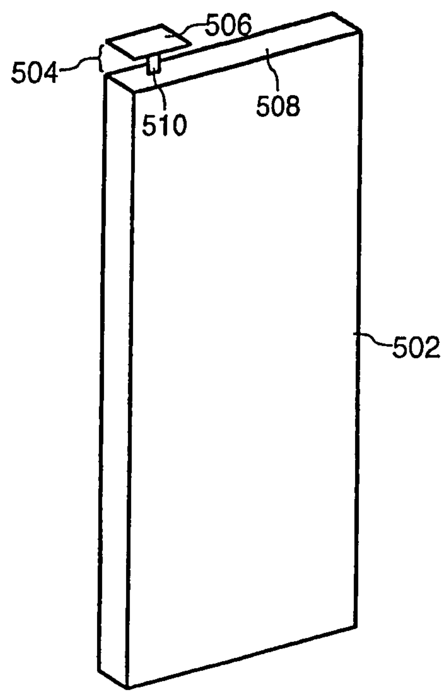
506
504
510
508
502

FIG. 5

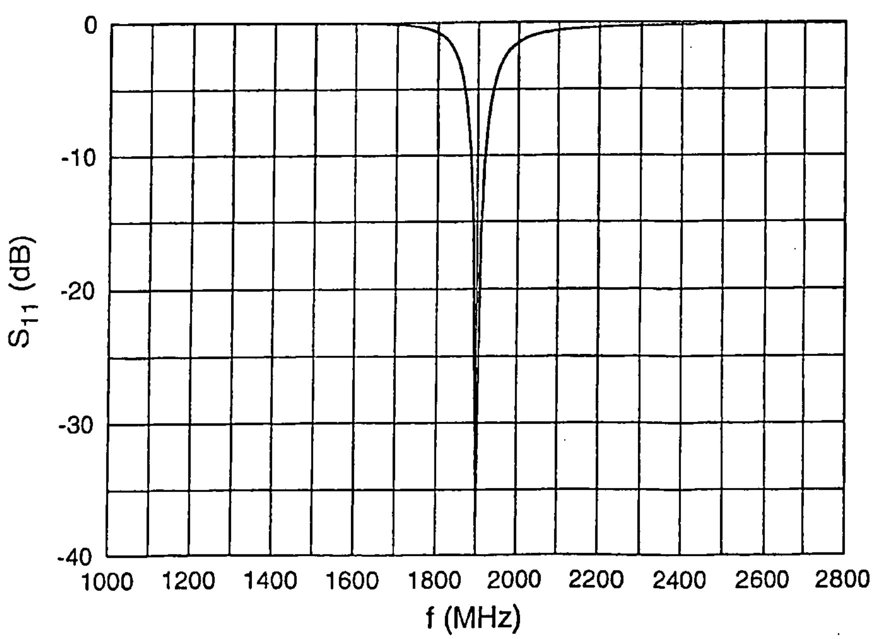
0
-10
-20
-30
-40
S_{11} (dB)
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
f (MHz)

FIG. 6

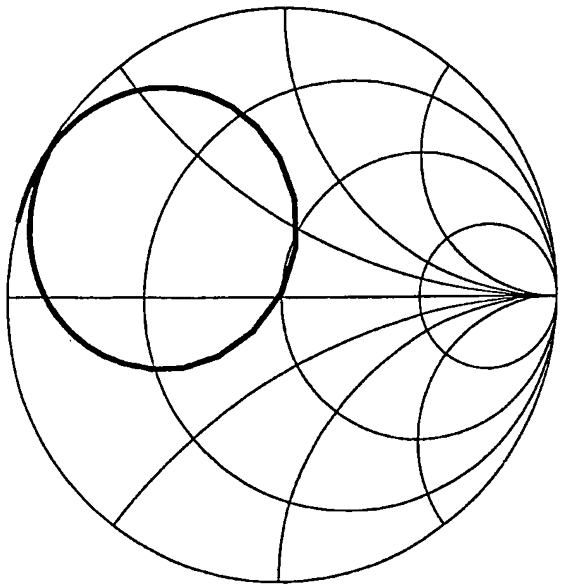

FIG. 7

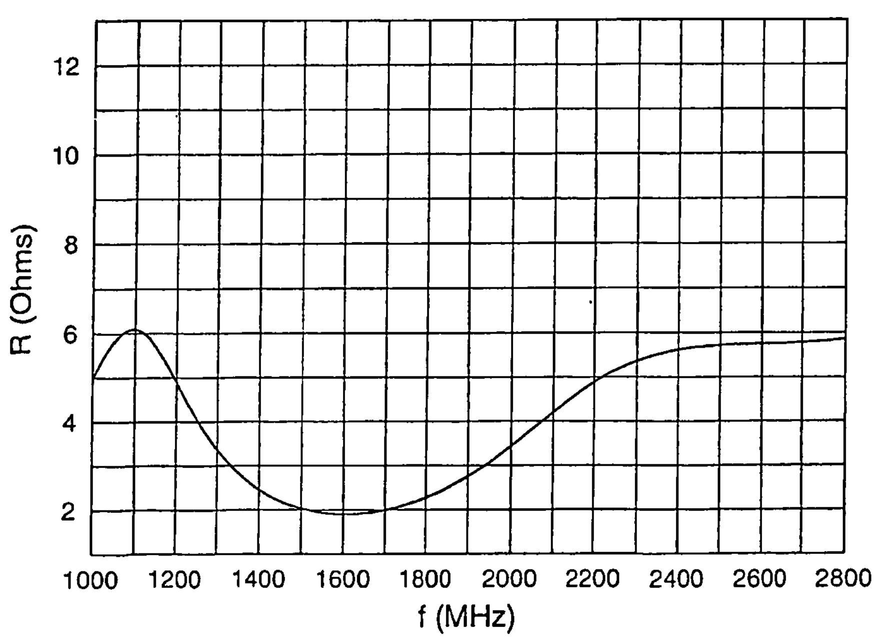
12
10
8
6
4
2
R (Ohms)
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
f (MHz)

FIG. 8

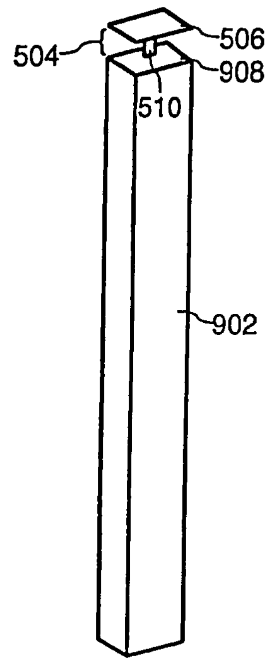
504
506
908
510
902

FIG. 9

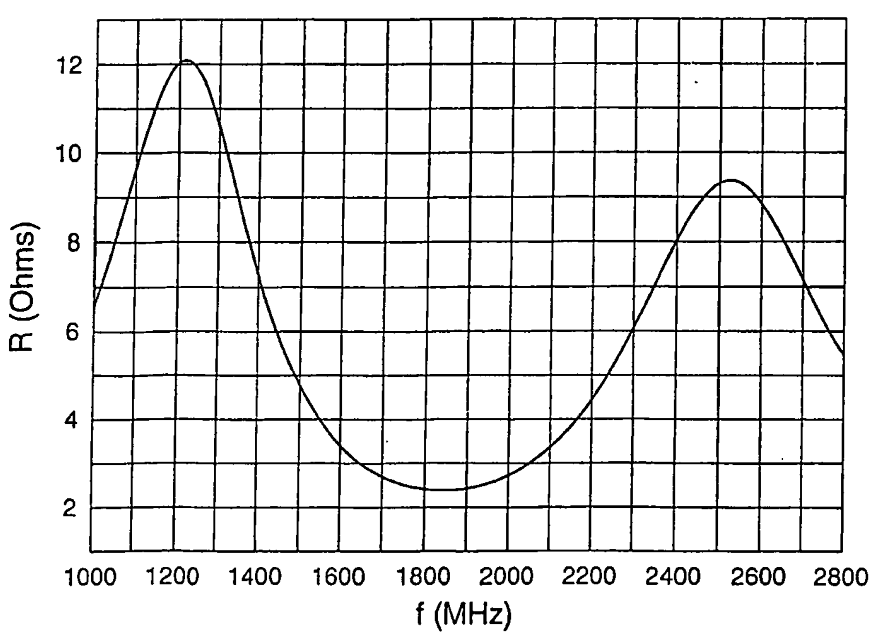
12
10
8
6
4
2
R (Ohms)
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
f (MHz)

FIG. 10

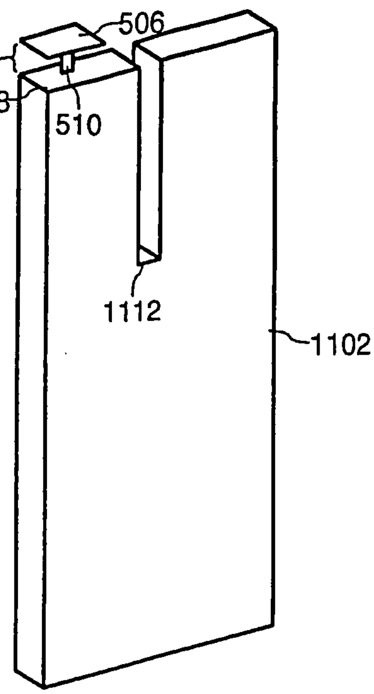
506
504
1108
510
1112
1102

FIG. 11

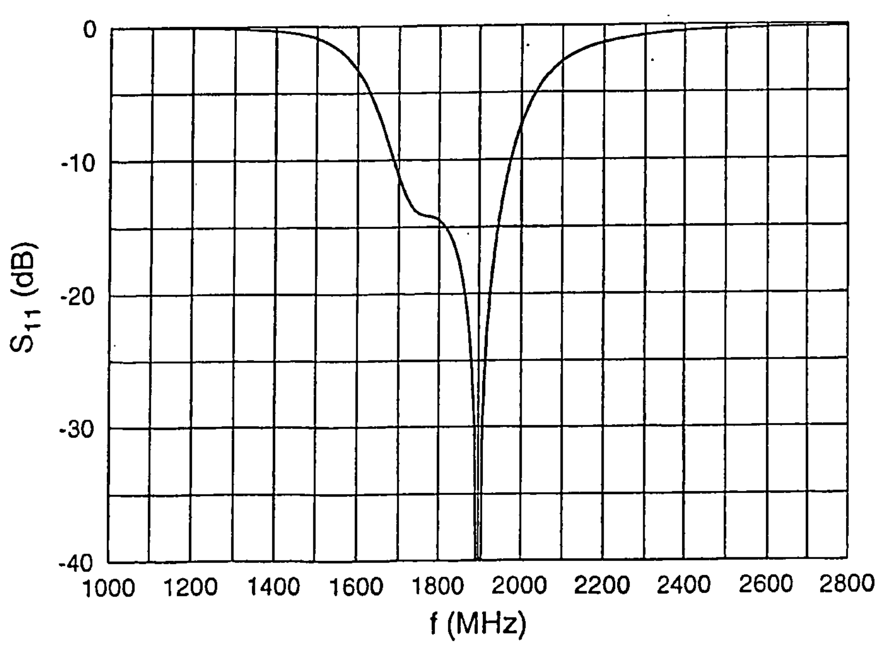
0
-10
-20
-30
-40
S_{11} (dB)
1000 1200 1400 1600 1800 2000 2200 2400 2600 2800
f (MHz)

FIG. 12

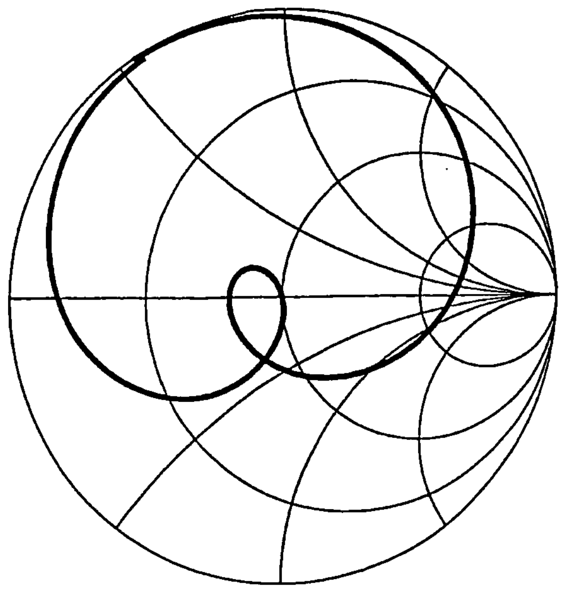

FIG. 13

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